



Space Weather Monitoring with GOES-16: Instruments and Data Products



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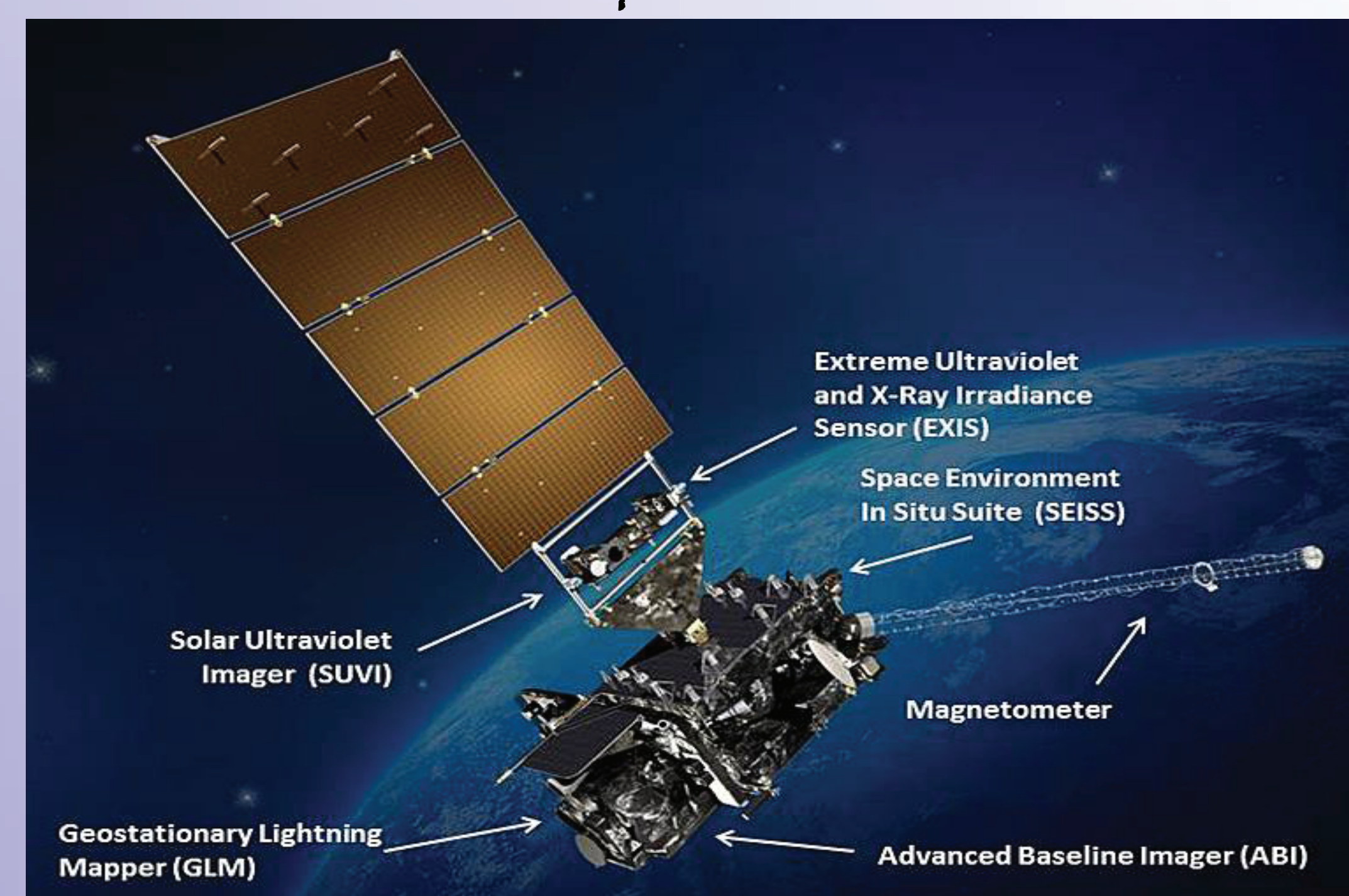
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Abstract

Since their inception in the 1970s, the NOAA GOES satellites have monitored the sources of space weather on the sun and the effects of space weather at Earth. The GOES-16 spacecraft, the first of four satellites as part of the GOES-R spacecraft series mission, was launched in November 2016. The space weather instruments on GOES-16 have significantly improved capabilities over older GOES instruments. They will image the sun's atmosphere in extreme-ultraviolet and monitor solar irradiance in X-rays and UV, solar energetic particles, magnetospheric energetic particles, galactic cosmic rays, and the Earth's magnetic field. These measurements are important for providing alerts and warnings to many worldwide customers, including the NOAA National Weather Service, satellite operators, the power utilities, and NASA's human activities in space. This presentation reviews the capabilities of the GOES-16 space weather instruments and presents initial post launch data along with a discussion of calibration activities and the current status of the instruments. We also describe the space weather Level 2+ products that are being developed for the GOES-R series including solar thematic maps, automated magnetopause crossing detection and spacecraft charging estimates. These new and continuing data products will be an integral part of NOAA space weather operations in the GOES-R era.

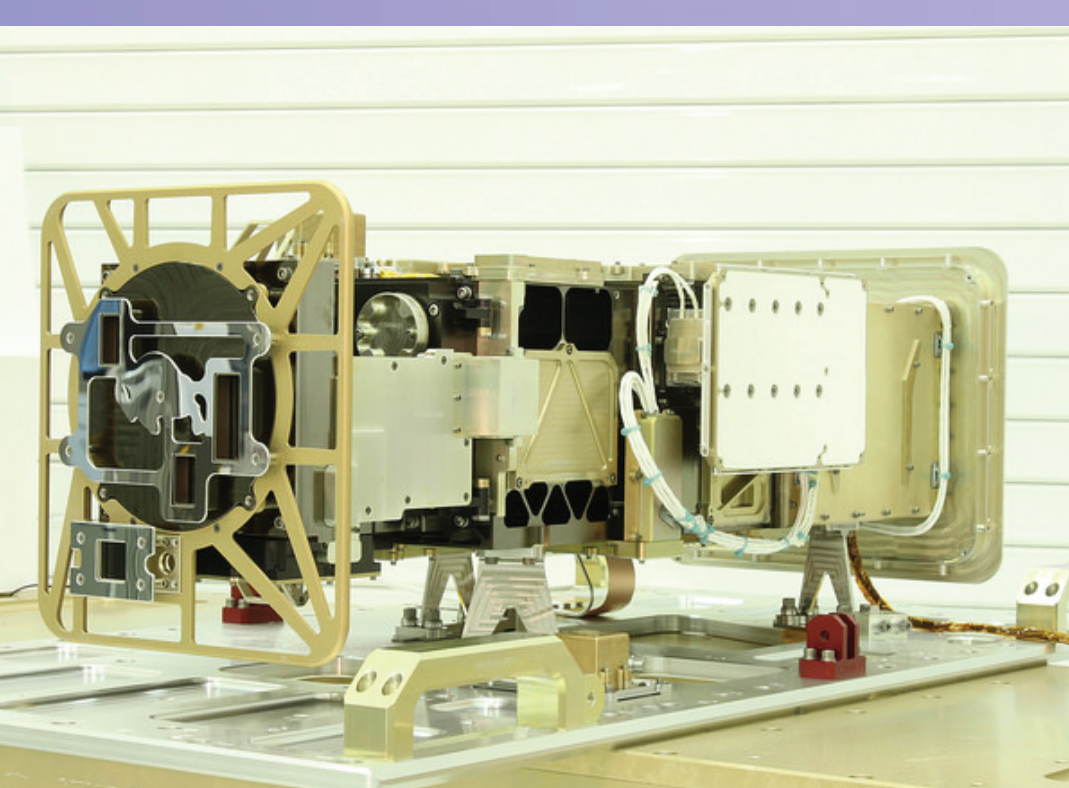
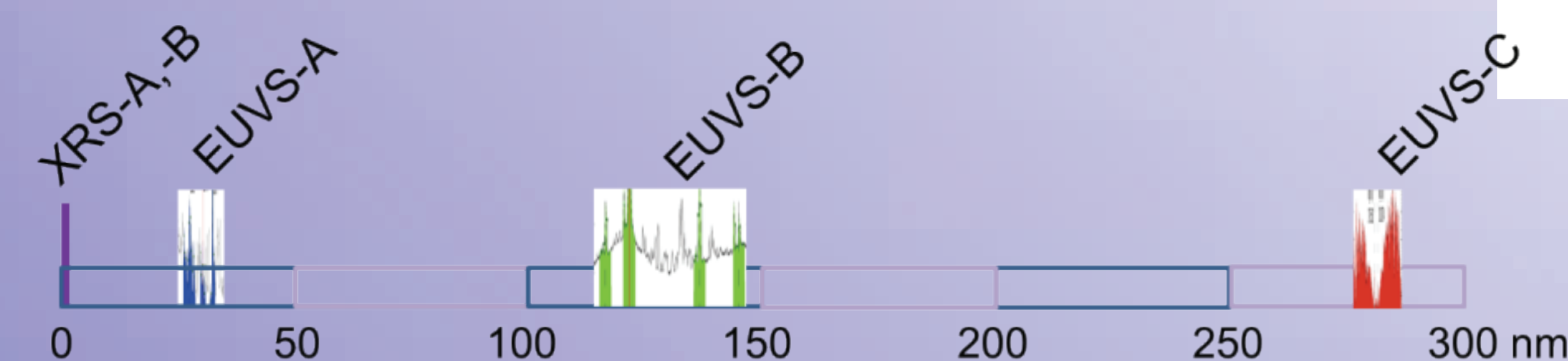
1. The GOES-16 Spacecraft



The GOES-16 is the first of the NOAA GOES-R series of satellites to be launched. Four of the six instruments onboard are space weather instruments (SUVI, EXIS, SEISS and Magnetometer or MAG).

2. Space Weather Instruments

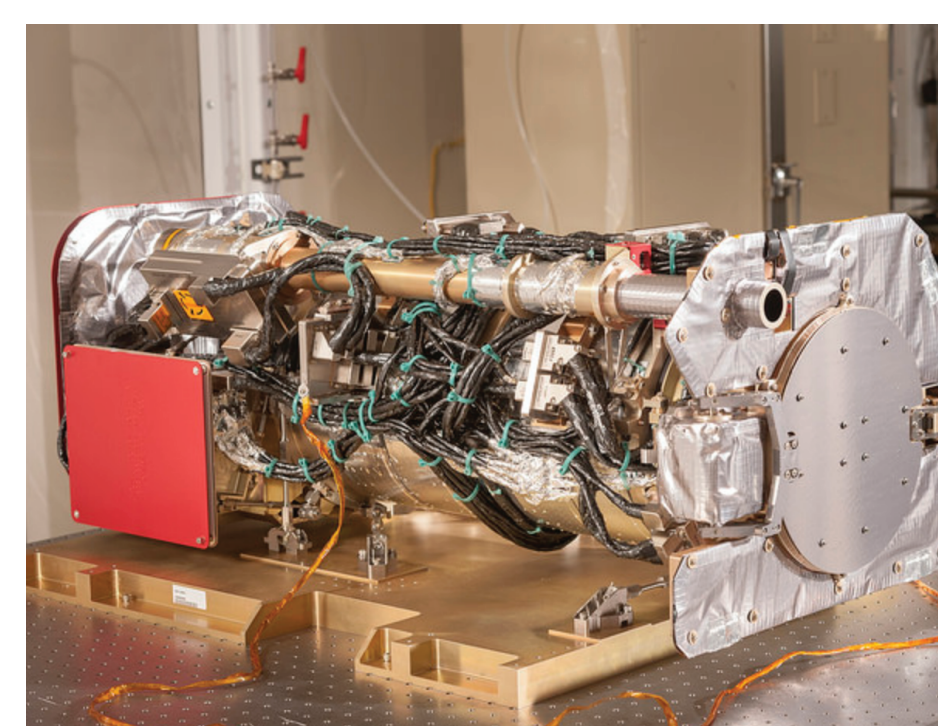
2.1 EXIS



The Extreme Ultraviolet and X ray Irradiance Sensors (EXIS) on the GOES-R series satellites are critical to understanding and monitoring solar irradiance in the upper atmosphere, that is, the power and effect of the Sun's electromagnetic radiation per unit of area. EXIS will be able to detect solar flares that could interrupt communications and reduce navigational accuracy, affecting satellites, high altitude airlines and power grids on Earth. EXIS has two main sensors, the Extreme Ultraviolet Sensor (EUVS) and the X-Ray Sensor (XRS), which will help scientists monitor activity on the Sun.

2.2 SUVI

Wavelength Log (Te)	94 Å 6.8	131 Å 7.0,7.2	171 Å 5.8	195 Å 6.1,7.3	284 Å 6.3	304 Å 4.7
Filaments						
Coronal Holes						
Active Region Complexity						
CMEs (e.g. dimming)						
Flare Location and Morphology						
Quiet Regions						



The Solar Ultraviolet Imager (SUVI) is a telescope that monitors the Sun in the extreme ultraviolet wavelength range. By observing the Sun, SUVI will be able to compile full disk solar images around the clock. It replaces the current GOES Solar X-ray Imager (SXI) instrument and represents a change in both spectral Imager (SXI) instrument and represents a change in both spectral coverage and spatial resolution over SXI.

2.3 SEISS

Magnetospheric Particle Sensor - Low (MPS-LO)

- Electrostatic analyzers
- 30 eV-30 keV ions and electrons
- 15 energy channels
- 14 angular zones (12 unique)

Magnetospheric Particle Sensor - High (MPS-HI)

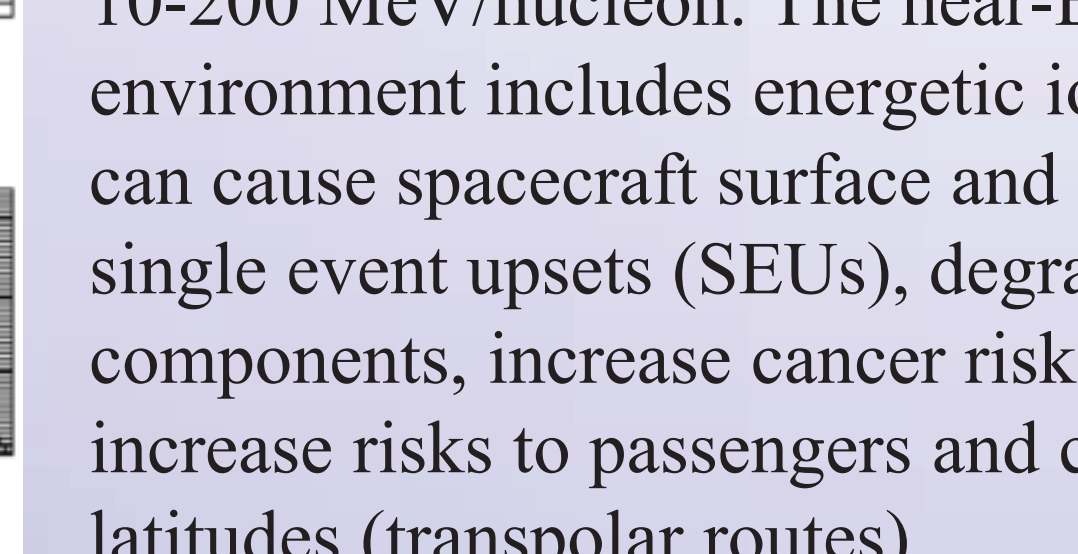
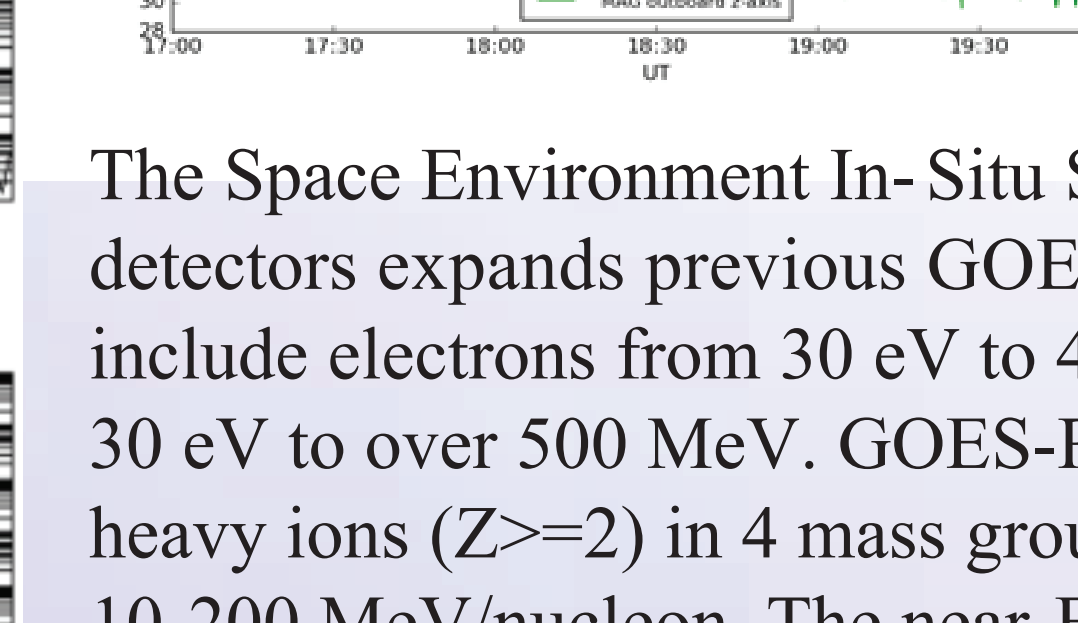
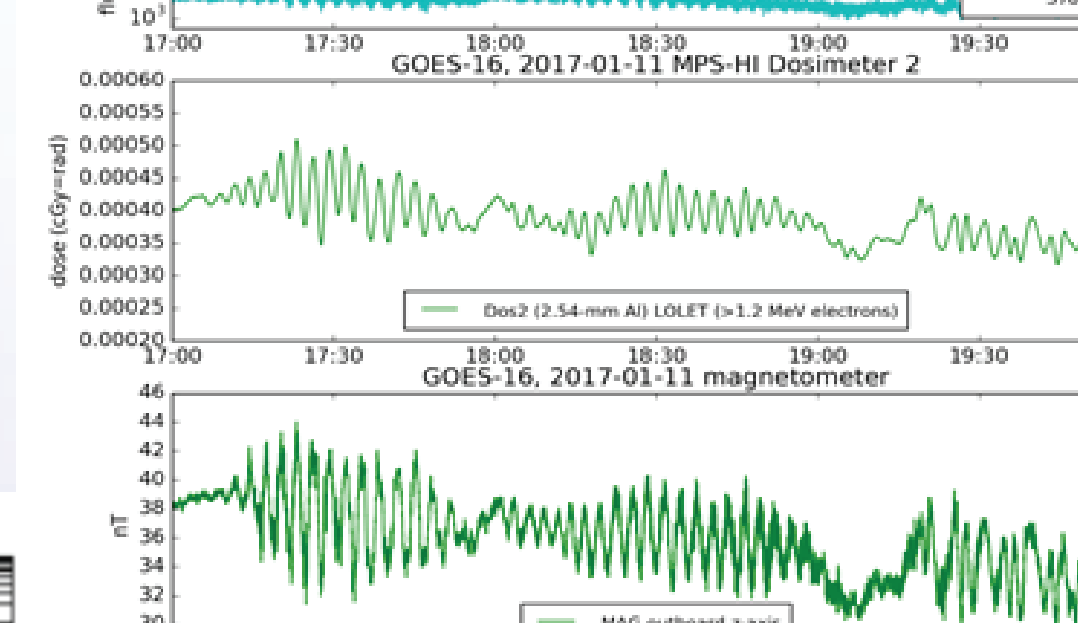
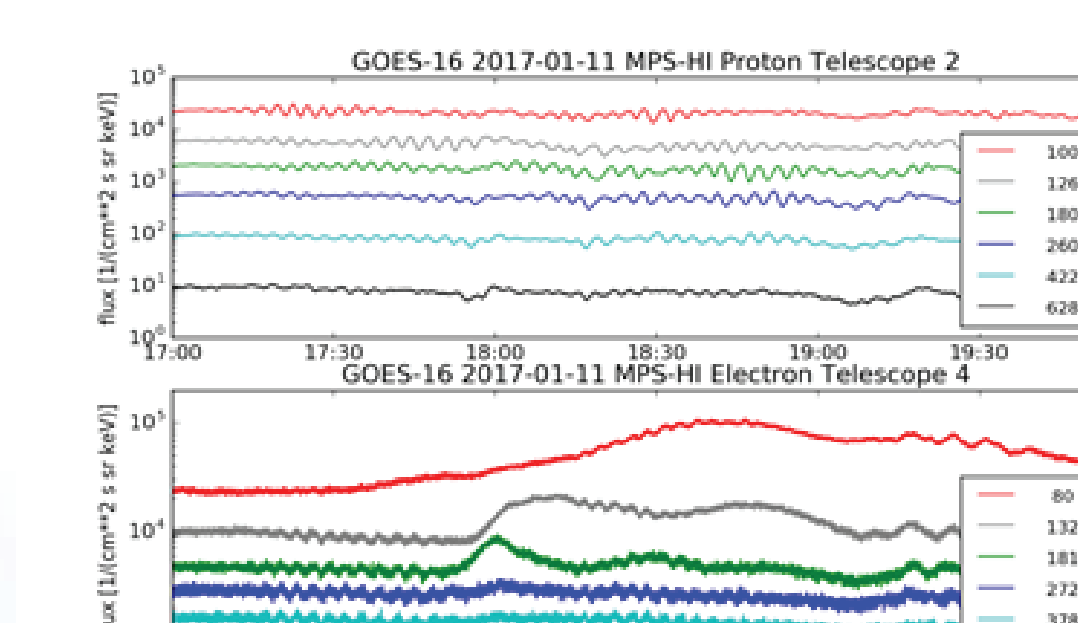
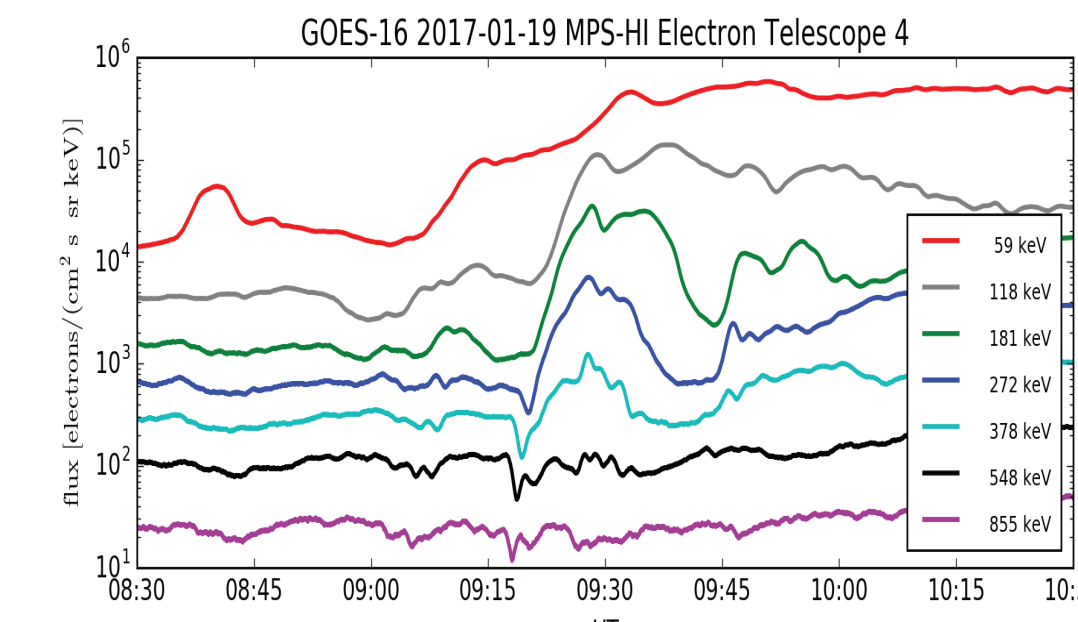
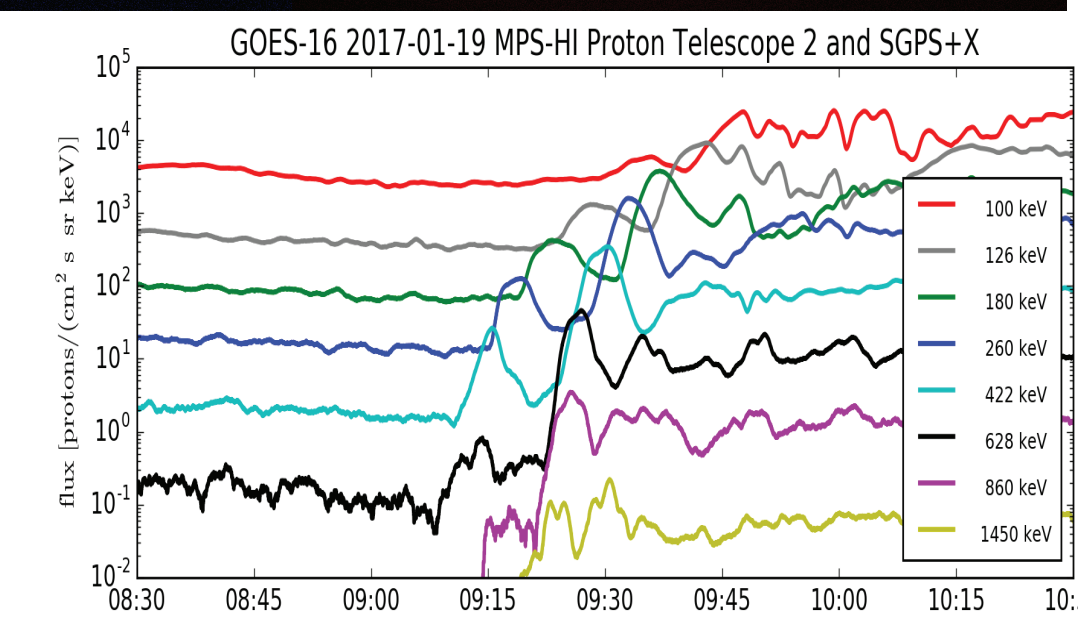
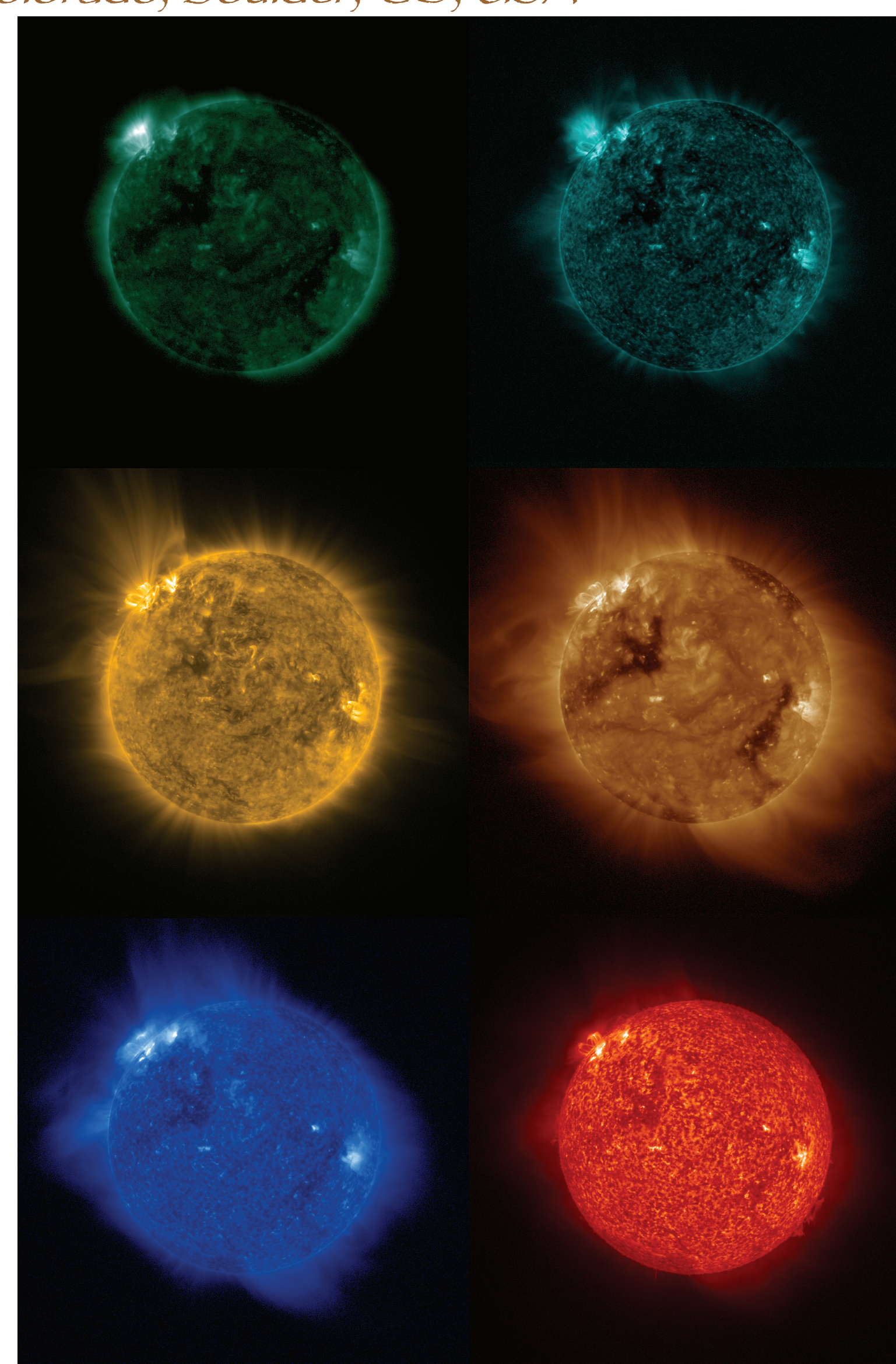
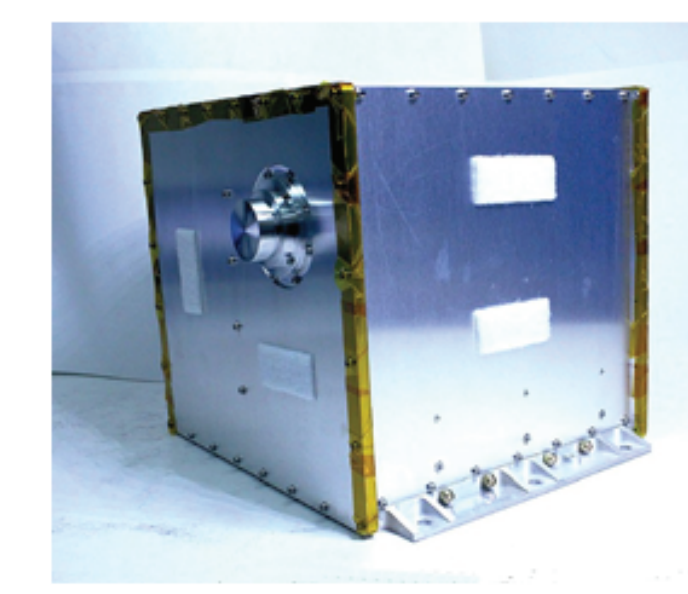
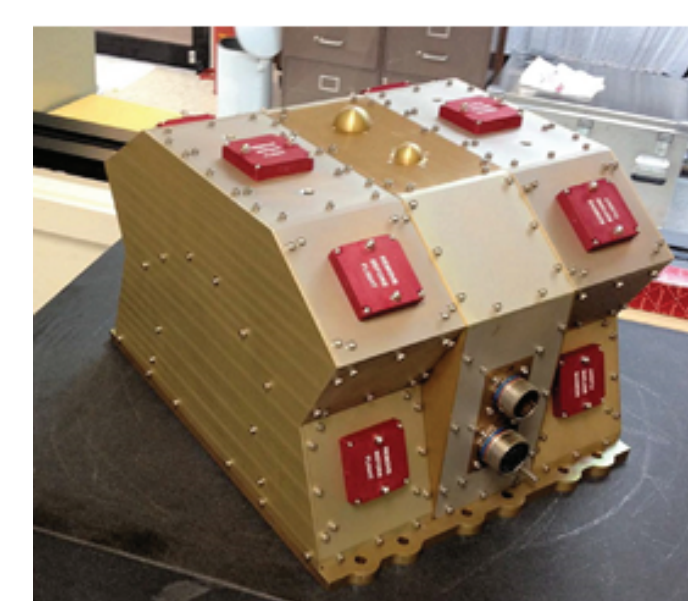
- 5 ion and 5 electron solid state telescopes
- 50 keV-4 MeV electrons in 11 differential channels, plus >2 MeV integral channel
- 80 keV-10 MeV protons in 11 energy bands
- Two hemispherical dosimeters:
 - 100 mil Al: >1.2 MeV electrons, >22 MeV protons
 - 200 mil Al: >2.8 MeV electrons, >37 MeV protons

Solar and Galactic Proton Sensor (SGPS)

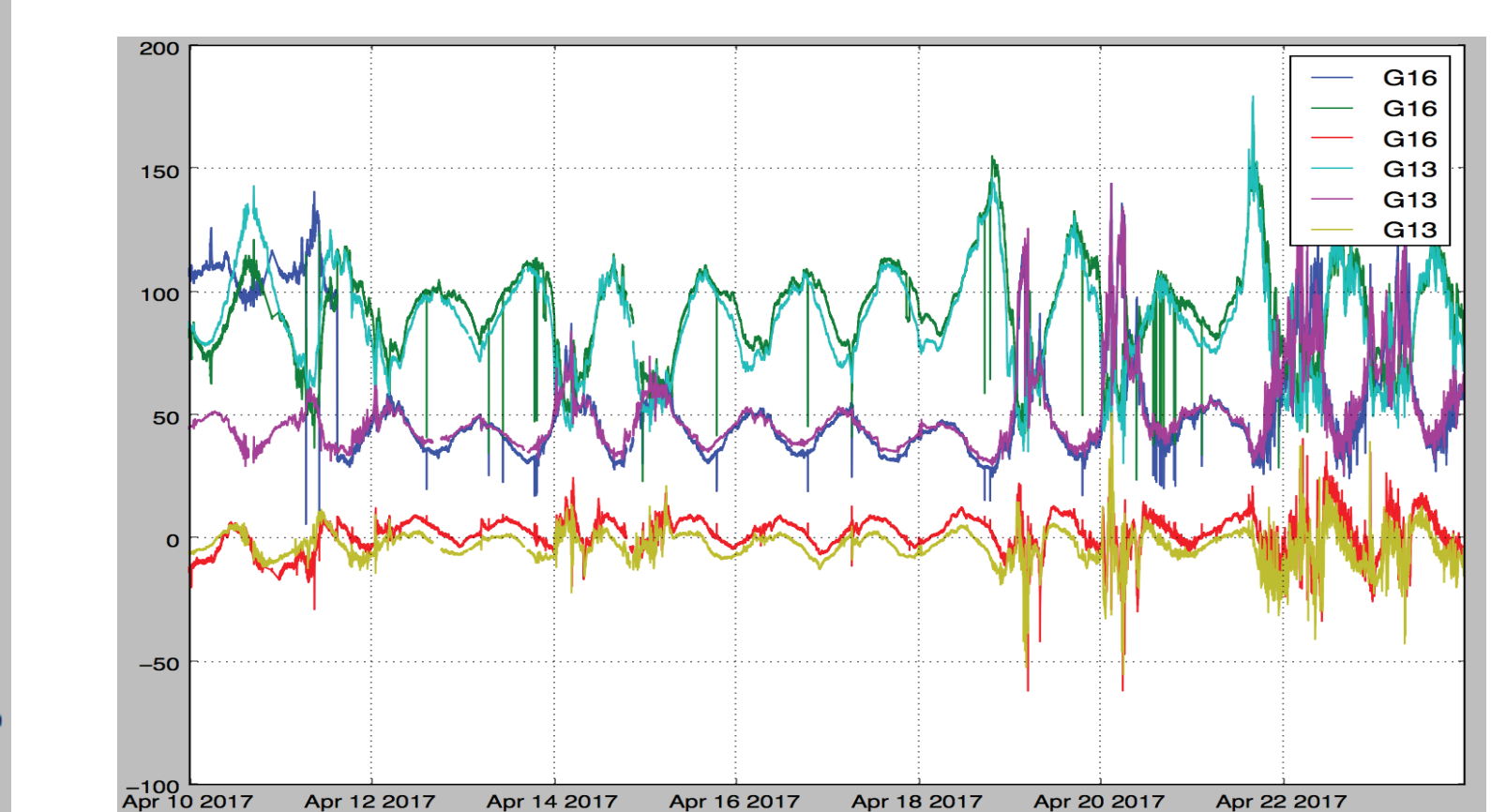
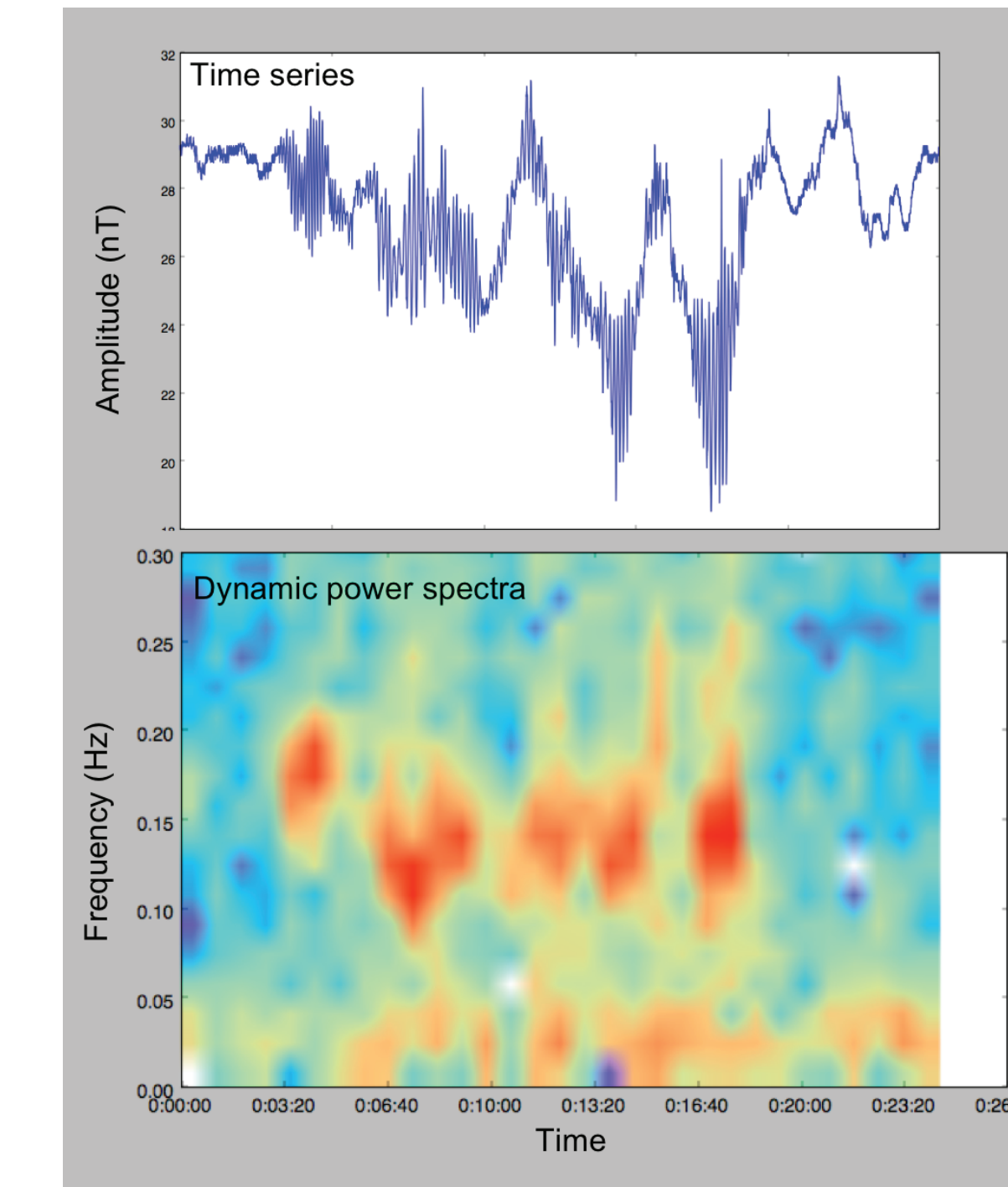
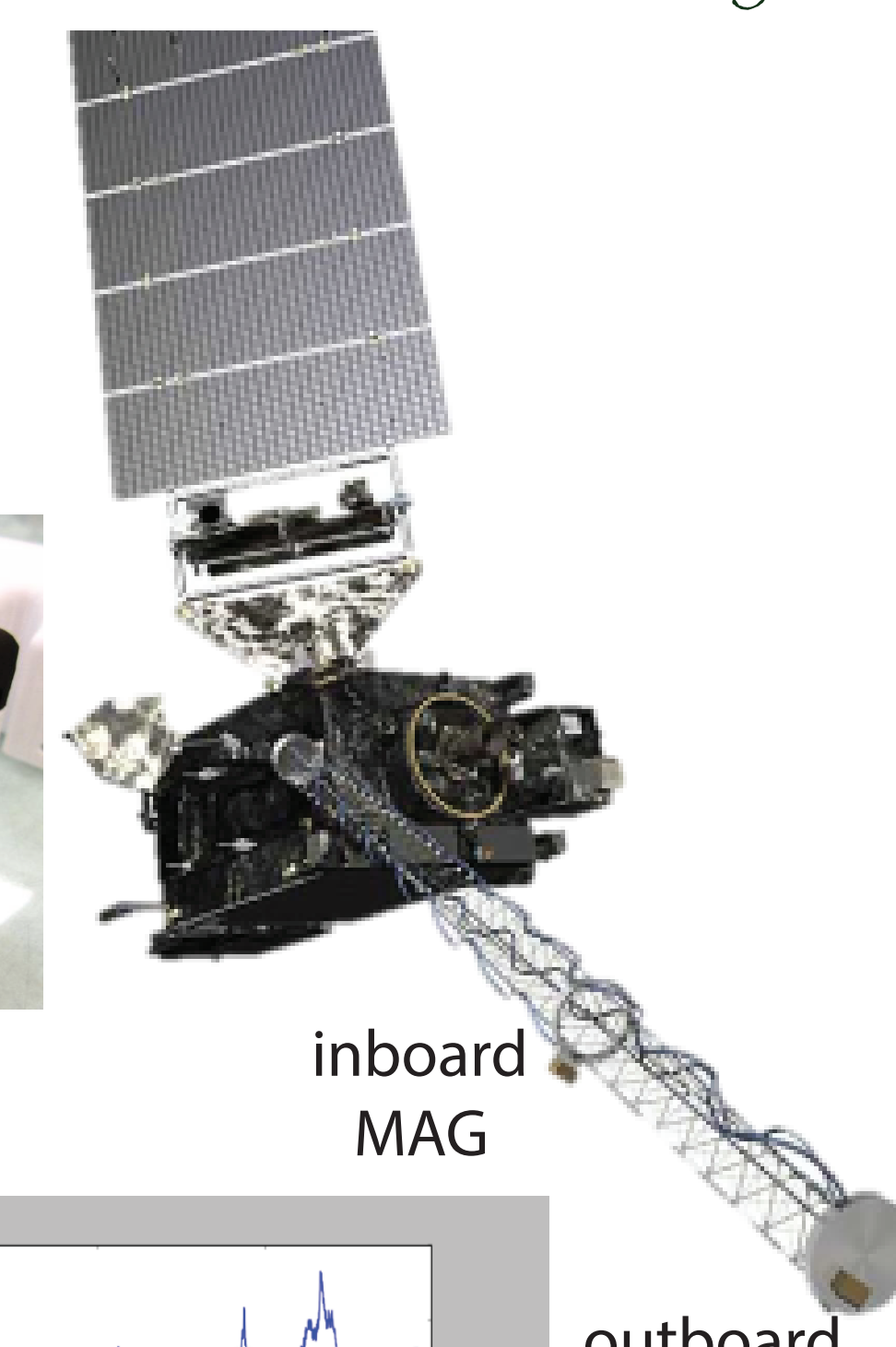
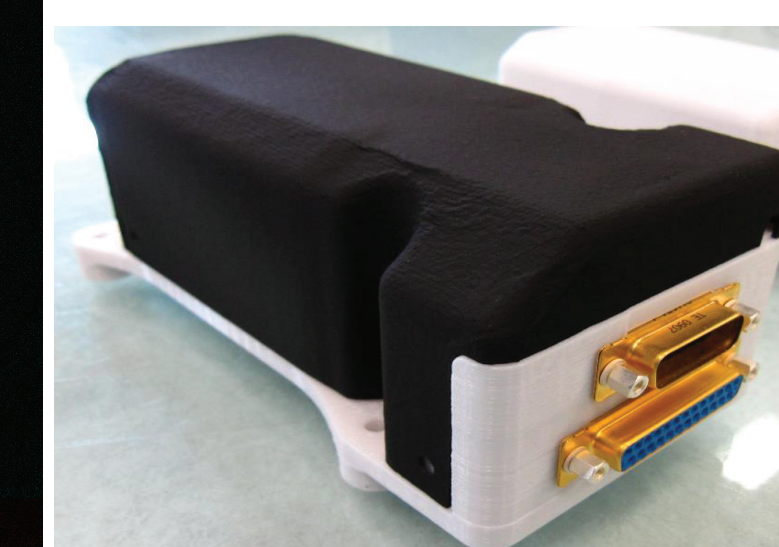
- 2 Units, one looking East and one West
- 3 solid state telescopes on each unit
- 1 MeV-500 MeV protons in 13 differential channels, plus >500 MeV integral channel
- 4 MeV-500 MeV alphas in 12 energy bands (not processed)

Energetic Heavy Ion Sensor (EHIS)

- 10-200 MeV/nucleon in 5 energy bands
- H, He, Z = 4-29 (Be-Cu), + CNO, Ne-S, Fe
- one look direction (radially outward)



2.4 MAG



The GOES magnetometers provide observations of the space environment magnetic field. The geomagnetic field measurements are important for providing alerts and warnings to many customer. GOES magnetometer data are also among the most widely used spacecraft data by the national and international research community. The GOESR magnetometer requirements are similar to those for previously flown instruments, measuring three components of the geomagnetic field with a resolution of least 0.016 nT, but with an improved sampling rate of 10 Hz. The MAG data are low pass filtered with 2.5 Hz cutoff compared to the 0.5 Hz cutoff of previous GOES magnetometers.

3. Level 1b Space Weather Products

SEISS:

- Energetic Heavy Ions
- Magnetospheric Electrons & Protons: Low Energy
- Magnetospheric Electrons: Med & High Energy
- Magnetospheric Protons: Med & High Energy
- Solar & Galactic Protons

MAG:

- Geomagnetic Field: Produced in multiple coordinate systems at 10 Hz resolution

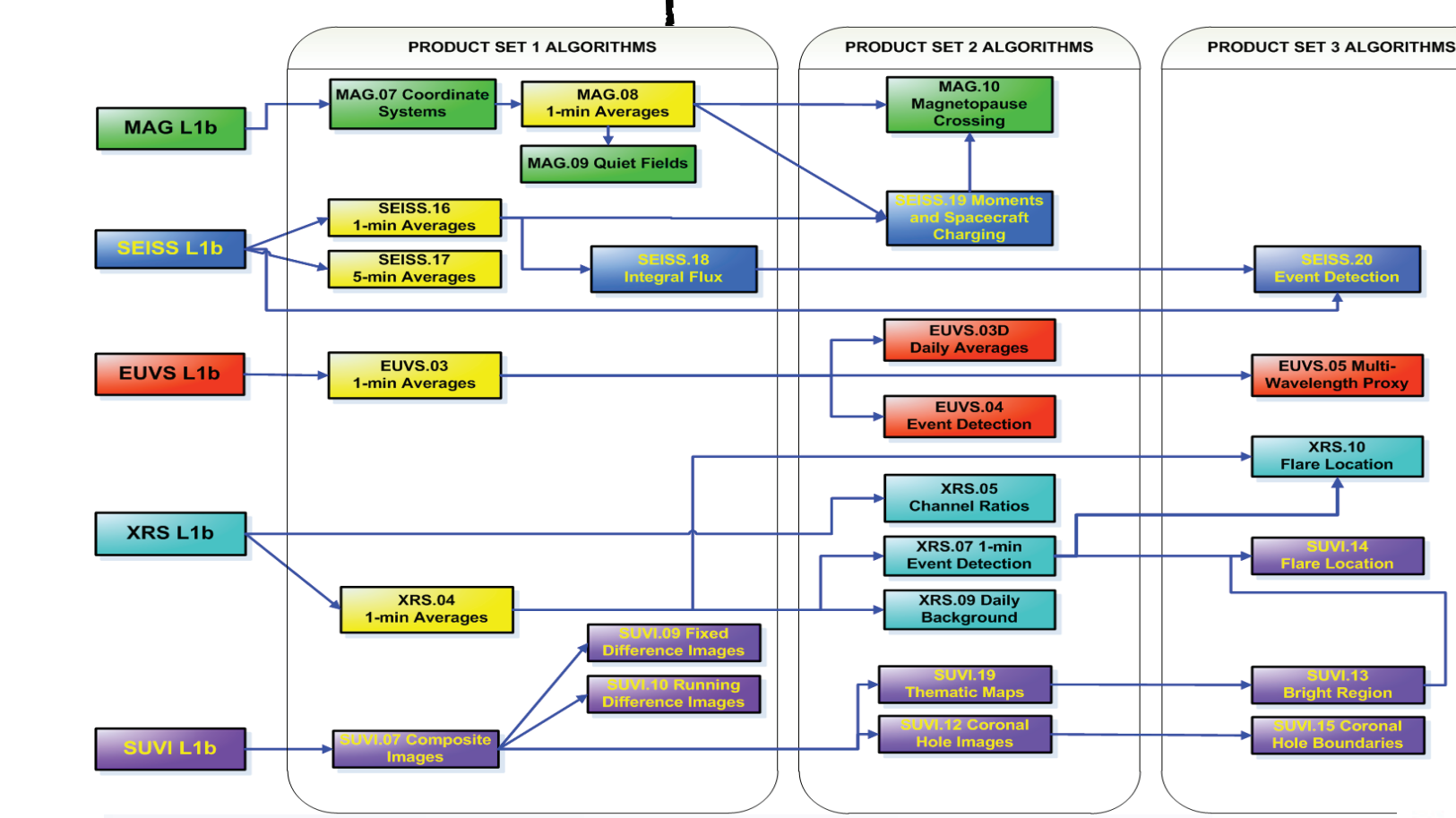
EXIS:

- Solar Flux: EUV
- Solar Flux: X-ray Irradiance

SUVI:

- Solar EUV Imagery

4. Level 2+ Space Weather Products and Data System



Along with cal/val efforts for L1b data, NGDC is continuing SWPC's efforts to develop and find implementation solutions for the Level 2+ space weather products. Part of this work includes calibrating/validating the L2+ products in terms of inputs and outputs. Below shows a precedent tree for the L2+ products.

Information on NCEI GOES-R data can be found at: <https://www.ngdc.noaa.gov/stp/satellite/goes-r.html>



SPADES is a demonstration system that demonstrates the implementation of the GOES-R Level 2+ space weather data products into operations.

